Report on
Liberal Studies C2 - Mathematics
Learning Outcome 2A
Course and Syllabi Assessment

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Introduction

Among many things, mathematics is a language like Chinese and Latin. It uses the tools of drawing, symbolic logic, procedure, and more. It is used for communication, to represent ideas, to make informed decisions, and to take action. The grammar and syntax include conventional notations in symbolic form and a well established deductive discourse that uses the rules of logic. Moreover, mathematical theory combines historical ideas developed over thousands of years. A good introduction to mathematics as a liberal art includes mathematical literacy in terms of procedural fluency (a careful education in the application of basic rules and methods) and conceptual understanding, in particular through the connection to other disciplines. This sentiment is captured in the Liberal Studies student learning outcomes in category C2.

Outcome 2A - Demonstrate the ability to interpret and use numerical data.

Although brief, the learning outcome statement requires two specific goals. First, to be able to translate to and from data and non-mathematical forms. Secondly, mathematical tools and techniques should be applied to manipulate the data. How this is taught and assessed is a function of the class and instructor.

Student expectation and performance can be gauged against Bloom's Taxonomy of Learning. For reference these can be defined as Remember Knowledge, Understand, Apply, Analyze, Evaluate, and Create. While juniors and seniors in mathematics and statistics should regularly evaluate and create, freshmen and sophomores in other majors are more likely to work at the levels at or below analyze. The distinction is critical in scoring student work and interpreting results.

The following report assesses to what extent MATH 101, 130, 146, and 170 meet the general goals of the Liberal Studies Program and the specific goals of the C2 (Mathematics) component of the Program. The assessment team used class syllabi and student work samples in their assessment.

MATH 101 – Mathematical Concepts - Introduction to applications of mathematics to daily experience. Topics to include statistical analysis and interpretation, applications to business, measurement methods, and selected topics of interest. (C2)

MATH 130 – College Algebra - Real number properties, solving equations, inequalities, systems of equations, functions, and graphs.

MATH 146 – Pre-Calculus - Functions using equations, graphs, and numerical data; linear, exponential, logarithmic, trigonometric, polynomial, and rational functions; transformations, compositions, inverses, and combinations of functions; trigonometry with identities.

MATH 170 – Applied Statistics - Descriptive statistics, exploratory data analysis, probability distributions, correlation, regression, estimation, and hypothesis testing.

Syllabus Review

A total of nine syllabi were reviewed. The syllabi were provided for each of the course sections being assessed. Observations for individual sections are listed. The syllabi content was good, although a few notes are provided for instructor feedback. Items reviewed were course descriptions, course objectives, and liberal studies objectives. Please note that only one copy of the MATH 101 and MATH 146 syllabi were provided and do not form a suitable basis for significant conclusions.

MATH 101 (Online - Date Unknown) – There is no mention of liberal studies, or liberal studies goals. Student learning objectives are not provided. The course learning objectives are not measurable.

MATH 130 (Fall 2016) – The course description should be updated to "Real number properties, solving equations, inequalities, systems of equations, functions, and graphs." The syllabus lists objectives for the course only. A list of learning objectives should be added. In addition, there is no mention of liberal studies.

MATH 130 (Spring 2017 example 1) – The 'Rationale/Purpose' should read 'Description' and updated to "Real number properties, solving equations, inequalities, systems of equations, functions, and graphs."

MATH 130 (Spring 2017 example 2) – The course description should be "Real number properties, solving equations, inequalities, systems of equations, functions, and graphs." The liberal studies learning objectives are missing the 7th item. The course objectives should be rewritten to match normal conventions. For example words like create, demonstrate, and interpret.

MATH 130 (Spring 2017 example 3) – The course description does not match the catalog. The liberal studies learning goal is reformatted to read "Students will be able to interpret and use numerical, written, oral, and visual data." This adds an 'and' which implies that all four must be satisfied simultaneously.

MATH 146 (Spring 2017) – There is no mention of liberal studies but the student learning objective list includes interpret and use.

MATH 170 (Spring 2017 example 1) – The liberal studies goals and objectives do not match or include the outcome 2a description.

MATH 170 (Spring 2017 example 2) – The course learning objectives should be rewritten as student learning outcomes.

MATH 170 (Spring 2017 example 3) – The course description expands the catalog text and adds an additional topic not listed in the other MATH 170 descriptions. The instructor is bound by the catalog text and should provide the required text and add additional

comments elsewhere. The course objectives should be rewritten as student learning outcomes. There is no mention of liberal studies.

Recommendation (Department) – The catalog description for MATH 101 lists '(C2)', but this is not used on the other courses. This should be consistently used or omitted.
Faculty teaching liberal study eligible courses should make sure that they refer to the Faculty Resource Handbook and the WCU syllabus template when preparing their syllabus prior to each semester. Moreover, there should be an occasional review of syllabi to provide faculty feedback, possibly as part of the Annual Faculty Evaluation (AFE) reviews.

Recommendation (Liberal Studies Committee) – The syllabus text used for Liberal studies objectives, goals, etc. was inconsistent in the example syllabi. Instructors should be reminded to refer to the University Syllabus Template if they are teaching a liberal studies eligible course.

Review of Student Work

Student work was reviewed by committee members using the rubric in Table 1. The interpretation of 'demonstrate' was left to the individual graders.

Table 1 – Rubric for the assessment of student work for SLO 2A

	Liberal Studies Student Learning Outcome 2A *Demonstrate the ability to interpret (a) and use (b) numerical data.* Each of the 2 sub-skills should be scored separately				
	Performance Levels				
Criteria	**Emerging (1)**	**Developing (2)**	**Achieving (3)**	**Exemplary (4)**	**N/A**
a. interpret	Student demonstrates the inability to interpret numerical data accurately and effectively.	Student demonstrates some ability to interpret numerical data effectively, but not with consistent accuracy.	Student demonstrates the ability to interpret numerical data effectively and does so consistently and accurately.	Student demonstrates a refined ability to interpret numerical data in effectively clear, insightful, and accurate ways that exceed expectations.	A score of N/A designates irrelevancy of the category to the assignment, or folders and/or content cannot be viewed or assessed.
b. use	Student demonstrates the inability to use numerical data accurately and effectively.	Student demonstrates some ability to use numerical data effectively, but is unable to do so with consistent accuracy.	Student demonstrates the ability to use numerical data effectively and does so consistently and accurately.	Student demonstrates a refined ability to use numerical data effectively in accurate, insightful, and precise ways that exceed expectations.	A score of N/A designates irrelevancy of the category to the assignment, or folders and/or content cannot be viewed or assessed.

<u>Recommendation (Liberal Studies Committee) - Making greater use of Bloom's taxonomy in communicating liberal studies outcomes and objectives would help guide instructors. This would also be of great value in assessing liberal studies outcomes.</u>

Each work product was assessed by two committee members in isolation and then compared as a group. The committee discussed and agreed on a number of factors that indicate student success in application of the rubric to assessment samples.

Example factors that were important in 'interpreting' were:

- Correctly assigning data to variables, in context.
- Correctly assigning meaning to numerical values.
- Correctly labeling graphs with titles, axes, units, legends, curves, etc.
- Identifying meaningful trends on graphs.
- Referring to data when drawing conclusions.
- Correctly selecting units and significant figures.

Example factors that were important in 'use' were:

- Correctly performing mathematical calculations with proper accuracy.
- Using spreadsheets to do calculations - note: This should not be confused with being provided spreadsheets with previously defined calculations.
- Generating graphs using data.
- Correctly selecting computation techniques.
- Demonstrating a clear understanding of calculations performed by spreadsheets, calculators, or other technological tools.
- Performing a sequential set of steps for calculation.

A total of 400+ samples of student work were provided. However, not all of these were graded. In particular, some assignments that did not require any numerical data were impossible to grade for interpretation and use. In a couple of cases the assignments only required one of the two outcomes. Table 2 contains the compiled data with scores by category, average, and standard deviation. The table also shows the goal for use and interpretation using Bloom's categories. It is important to note that the absolute values of the scores is subjective and should not alone be the basis for recommendation. This means that the values may appear low but, for a freshman, a score of 2 out of 4 might be considered good.

Strength: this particular liberal studies objective does lend itself to an objective assessment of student products with separate reviewers reaching similar and consistent scores.

Table 2 – Numerical Scores for Student Sample Work

Work Number Range	MATH Course	Use Bloom Object.	Use Avg.	Use Std. Dev.	Interp. Bloom Object.	Interp. Avg.	Interp. Std. Dev.	Notes
1xxx	130	Remember	NA	NA	Understand	NA	NA	See notes
2001-38	170	Apply	2.75	0.5	Analyze	2.210	0.559	
3001-38	170	Apply	NA	NA	Analyze	1.792	0.743	
4xxx								Not Provided
5xxx								Not Provided
6001-61			2.4	0.715		2.142	0.802	
7001-49	170	Apply	2.041	0.841	Analyze	1.794	0.763	
8001-27	170	Apply	2.815	0.826	Analyze	2.25	0.926	
9001-26	130	Apply	2.471	0.703	Analyze	2.365	0.715	
10001-47	101	Understand	2.906	0.701	Understand	2.744	0.712	
11001-69	170	Apply	1.946	0.487	Apply	1.504	0.518	

Notes for Assignment Range 1000:

- These assignments were written as qualitative essays about the potential use of math in their future careers. While the students did reference mathematical topics in general they did not use equations or numerical data in the papers and the committee felt that the exhibits were not suitable for assessing the criteria.

Notes for Assignment Range 2000 and 3000:

- These examples were based on a spreadsheet provided by the instructor. Students were asked to change numbers to see the outcomes on GPA, but did not need to formulate or examine the underlying calculations. There were comments that allowed assessment of criteria 2A, 'use'.
    - The students were able to explain the effect of percentage weights through iterations and the final grade.
    - Many students were able to identify the grades they needed to obtain to meet the goals of an A or B grade.
    - The assignment did not require a specific outcome asking the students to mathematically analyse the results.

Notes for Assignment Range 6000:

- These assignments used well recognized techniques and were used as a good indicator of student performance.
    - Students were able to use the data at a higher rate than the interpret criterion. In particular the sign of a slope was confusing to approximately half.
    - This problem required that students entered data into a calculator and produce an equation.
    - The linear regression factor was used to estimate equation quality (fit).

Notes for Assignment Range 7000:

- This assignment had very specific instructions for the students to follow. It involved creation of graphs and best fit lines/curves with spreadsheets. Students were asked to make conclusions.
    - The assignment required graph creation. Indicators of ability included axes labels, curve shapes, etc.
    - The majority of students could find correlation but fewer were able to synthesis into meaningful statements.

Notes for Assignment Range 8000 1e):

- This problem was very effective procedurally relating Z-scores forward and back. Students were less likely to differentiate overall GPA scores from derived Z values. In particular the use of the Z-score as more meaningful than absolute GPA values on different scales.

Notes for Assignment Range 9000:

- These problems provided a good example of both of the learning outcome criteria. It could serve as an example for others to consider.

Notes for Assignment Range 10000:

- The project reports had varying products including the time value of money for mortgage/loan calculations, and population growth projections.
    - There was a combination of solutions that used formulas or internet based tools instead.
    - The format of the assignment was a little more open ended but seemed to engage students more.
    - Allowed students to use and interpret data in their real lives.

Notes for Assignment Range 11000:

- The assignment focused on the application of statistical operations for hypothesis testing.
    - The use of numbers was much more straightforward in this problem. Accordingly the students scored somewhat lower in the interpret metric.

Discussions followed the grading process. A major concern is that the samples of work provided were probably not representative of the normal work being done in the math classes. The extreme examples were essays about math without numbers and calculations. While these have academic merit, they do not show the 'interpretation and use of data' expected in liberal studies. This may be the result of misinterpretation of the liberal studies faculty handbook statement that "Emphasis will be on the development of conceptual understanding rather than on computational drill. An assignment in which students display an application of mathematics and/or analytical problem solving will be required."

Recommendation (Liberal Studies Committee) – The C2 criteria for liberal studies should be discussed with the math instructors so that in the next round of assessment assignments "students display an application of mathematics and/or analytical problem solving will be required."

Recommendation (Liberal Studies Committee) - The liberal studies committee should consider revising the language describing the C2 objective "display an application of mathematics and/or analytical problem solving" to more specific guidelines for faculty to understand that assessment artifacts are expected to demonstrate students' mathematical literacy and their ability to communicate, use and interpret mathematics in contextual situations. We suggest that the term "display" be changed to "engage in" and that "alone" be added after "drill".

> C2, Mathematics (3 hours): The Mathematics course will serve as an introduction to applications of mathematics to daily experience. Emphasis will be on the development of conceptual understanding rather than on computational drill ***alone***. An assignment in which students ***engage in*** an application of mathematics and/or analytical problem solving will be required. A student may satisfy the requirement by passing MATH 321 or any 100-level MATH course except for MATH 190-199. Every student must take a college mathematics course or receive college level transfer credit in mathematics.

Computational tools are the necessary foundations built in secondary education Mathematics courses, but applications of mathematics at the university level go beyond basic skills into higher-order reasoning and analysis, and no student should be considered educated without exposure to the use of mathematics in these contexts.

Conclusion

The role of the math department is very important and they have done an excellent job of preparing our students. The evidence reviewed does not indicate any need for pedagogical change. However, the committee did find that there was some misunderstanding of the role of math courses as a core foundation for the liberal arts. We hope that the math department will continue to teach our students the mathematical tools that they need to participate in, and shape, modern society.

Appendix A – Relevant C2 Text From Liberal Studies Handbook

Core Classes: (pg. 10)
C2. Mathematics (3 hours)

- Satisfied if student passes any MATH course 101 or higher, except for MATH 190- 199, MATH 301, and MATH 400)
- MATH 101 - Mathematical Concepts Credits: (3)

Liberal Studies Checksheet: (pg. 13)

Western Carolina University
MASTER LIBERAL STUDIES CHECK-SHEET
(Courses are 3 credit hours unless noted otherwise.)

THE CORE (21 HOURS)

C1. Writing, 6 hours
ENGL 101 Writing and Rhetoric (Freshman Year)
ENGL 202 Writing and Critical Inquiry (Sophomore Year)

C2. Mathematics, 3 hours
MATH 101 Mathematical Concepts
MATH 130 College Algebra
MATH 170 Applied Statistics
(Satisfied if student passes any MATH course 101 or higher, except for MATH 190-199, MATH 301, and MATH 400.)

EDCI 191 Teachers, Schools, and Society
ENGL 190 Literature
ENGL 191 Creative Writing
ENGL 192 Motion Picture Studies
ENGR 190 Technology Systems
ENGR 199 Engineering Seminar Freshman
ENT 195 Social Entrepreneurship: Creati
ENVH 190 From Black Death to Bioterrori
FIN 195 You and Your Money
GEOL 191 Geology, Landscapes, & the Hu
GER 190 Triumph & Tragedy in Modern C
HIST 190 History Topics

Core Classes: (pg. 16)

1) C2-Mathematics - Students may get credit for this category by passing any university-level math class (MATH 100, MATH 190-199, MATH 301 and MATH 400 will not count). If the math class is needed for the major, students are permitted to "double dip"; however, they may need to take an additional class as a general elective to earn the total hours needed for their degree.
   Transfer credit tip: Course must be college level, not remedial or preparatory in nature.

Liberal Studies Course Design: (pg. 22)
All Liberal Studies course syllabi must include the following:
In this course, you will:

- Demonstrate the ability to locate, analyze, synthesize, and evaluate information;
- Demonstrate the ability to interpret and use numerical, written, oral and visual data;
- Demonstrate the ability to read with comprehension, and to write and speak clearly, coherently, and effectively as well as to adapt modes of communication appropriate to an audience; Liberal Studies at Western Carolina University
- Demonstrate the ability to critically analyze arguments; demonstrate the ability to recognize behaviors and define choices that affect lifelong well-being;
- Demonstrate an understanding of
    - Past human experiences and ability to relate them to the present:
    - Different contemporary cultures and their interrelationships;
    - Issues involving social institutions, interpersonal and group dynamics, human development and behavior, and cultural diversity; scientific concepts and methods as well as contemporary issues in science and technology;

- Cultural heritage through its expressions of wisdom, literature and art and their roles in the process of self and social understanding.

Core Objectives: (pg. 24)

C2, Mathematics (3 hours): The Mathematics course will serve as an introduction to applications of mathematics to daily experience. Emphasis will be on the development of conceptual understanding rather than on computational drill. An assignment in which students display an application of mathematics and/or analytical problem solving will be required. A student may satisfy the requirement by passing MATH 321 or any 100-level MATH course except for MATH 190-199. Every student must take a college mathematics course or receive college level transfer credit in mathematics. Computational tools are the necessary foundations built in secondary education Mathematics courses, but applications of mathematics at the university level go beyond basic skills into higher-order reasoning and analysis, and no student should be considered educated without exposure to the use of mathematics in these contexts.

Appendix B – Recommendations from 2007 Assessment Report

When reviewing the instruction set for the student products, the task force observed that true/false and multiple choice questions with no opportunity for explanation, or response are not good instruments for assessing the goals and objectives, especially the objective "Student learning will be focused on the development of conceptual understanding rather than computational drill."

Most student work did not reflect the deeper application of their project. For instance, many students completed a project performing a statistical analysis on TV commercials. Only a few students drew real conclusions about the length, subject matter, timing, etc. of these commercials. Some student work showed an incorrect application of the tools. Example: one "pie chart" showed the length of time of 4 commercials, which were each 30 seconds; naturally, this chart showed four equal pie slices. The task force recommends that instructors build more "mathematical analysis of observations" into their rubrics.

The task force believes that limiting the project to a statistics theme seems unnecessary. The C2 objectives could still be satisfied with a broader range of project topics.

Instructors should put objectives on their syllabi, covering both the Liberal Studies and C2 mathematics objectives.

In principle, a thorough assessment of the C2 liberal studies requirement should include data from all courses a student may be use to satisfy the requirement. (The task force was only provided data for MATH 101.) However, gathering data from all such courses would prove to be unwieldy. The task force recommends that future assessments should include only the four mathematics courses used most frequently to satisfy the C2 requirement. These are MATH 101 (21% of sections of 100 level courses offered in 2006-07), MATH 130 (17%), MATH 135 (18%), and MATH 170 (18%). Furthermore, the Department of Mathematics should submit to the Liberal Arts Oversight Committee a proposal to designate MATH 130, 135, and 170 as courses that explicitly satisfy the C2 requirement.

There is a disjoint present in the wording of the Liberal Studies Document and the courses in the catalog that may satisfy the C2 requirement. Namely, not all courses have a statistical component, but all feature applications of mathematics and the opportunity to synthesize and analyze mathematical results. Thus, the task force recommends to the Liberal Arts Oversight Committee the following changes to the C2 requirement:

From the Liberal Studies Document:

Mathematics (3 hours): The Mathematics course will serve as an introduction to applications of mathematics to daily experience. Emphasis will be on the development of conceptual understanding rather than on computational drill. <u>Projects in which students do mathematical analysis of observations will be required. A significant proportion of the analysis will be statistically based. Students who are placed into, and wish to take, a</u>

higher level course will satisfy this requirement by passing the higher level course. However, every student must take a college mathematics course or receive college level transfer credit for a course taken at another institution. Computational tools are the necessary foundations built in secondary education Mathematics courses, but applications of mathematics at the university level go beyond basic skills into higher order reasoning and analysis, and no student should be considered educated without exposure to the use of mathematics in these contexts.

Recommendation: Change underlined part to: "An assignment in which students display an application of mathematics will be required. This assignment will address an application of mathematics, which may include statistics, optimization, linear regression, the mathematics of motion, or the mathematics of population growth."

Recommendation: Append to the end of the statement: "(Alternatively, a student may satisfy the requirement by passing MATH 230 or any 100 level MATH course except for MATH 190-199.)"

Appendix C – Selected Section of the Liberal Studies Assessment Rubrics

Appendix 1

Liberal Studies Assessment Rubrics

Fall 2014

The Following rubrics have been constructed in order to facilitate the determination of how well students are achieving the outcomes mandated by the Liberal Studies Program.

For phase one of the LS assessment, all LS instructors will be asked to identify which of the following outcomes are met in the courses they teach. According to the current LS document, students should be able to demonstrate achievement in the following areas:

1. Demonstrate the ability to locate, analyze, synthesize, and evaluate information;
2. Demonstrate the ability to interpret and use numerical, written, oral and visual data;
3. Demonstrate the ability to read with comprehension, and to write and speak clearly, coherently, and effectively as well as to adapt modes of communication appropriate to an audience;
4. Demonstrate the ability to critically analyze arguments;
5. Demonstrate the ability to recognize behaviors and define choices that affect lifelong well-being;
6. Demonstrate an understanding of
    a. Past human experiences and ability to relate them to the present;
    b. Different contemporary cultures and their interrelationships;
    c. Issues involving social institutions, interpersonal and group dynamics, human development and behavior, and cultural diversity;
    d. Scientific concepts and methods as well as contemporary issues in science and technology;
    e. Cultural heritage through its expressions of wisdom, literature and art and their roles in the process of self and social understanding.
7. Demonstrate an excitement for and love of learning.

For phase two, a sample of student work will be collected and instructors will be asked to identify one of the following rubrics, i.e. the one that best applies to the particular assignment to which the student is responding. These rubrics include all of the outcomes mandated in the outcomes, but they have been divided into further delineated categories in order to construct workable and assessable tools for assessing the outcomes for the LS Program.

1. Demonstrate the ability to locate, analyze, synthesize, and evaluate information;
2. Demonstrate the ability to
    a. Interpret and use numerical, data;
    b. Interpret and use written data;
    c. Interpret and use oral data;
    d. Interpret and use visual data;
3. Demonstrate the ability to
    a. Read difficult texts with comprehension;
    b. Write clearly, coherently, and effectively as well as to adapt modes of communication appropriate to an audience;
    c. Speak clearly, coherently, and effectively as well as to adapt modes of communication appropriate to an audience
4. Demonstrate the ability to critically analyze arguments;
5. Demonstrate the ability to recognize behaviors and define choices that affect lifelong well-being;

2b Demonstrate the ability to interpret and use written data				
No Score	**Emerging**	**Developing**	**Achieving**	**Exemplary**
A score of X designates irrelevancy of the category to the assignment, or folders and/or content cannot be viewed or assessed.	Student demonstrates inability to interpret and use written data effectively.	Student demonstrates some ability to interpret or use written data effectively, but does not demonstrate ability in both skills.	Student demonstrates the ability to use and interpret written data effectively.	Student demonstrates a refined ability to use and interpret written data in clear, thoughtful, and precise ways that exceed expectations.
X	**1**	**2**	**3**	**4**

2c Demonstrate the ability to interpret and use oral data				
No Score	**Emerging**	**Developing**	**Achieving**	**Exemplary**
A score of X designates irrelevancy of the category to the assignment, or folders and/or content cannot be viewed or assessed.	Student demonstrates inability to interpret and use oral data effectively.	Student demonstrates some ability to interpret or use oral data effectively, but does not demonstrate ability in both skills.	Student demonstrates the ability to use and interpret oral data effectively.	Student demonstrates a refined ability to use and interpret oral data in clear, thoughtful, and precise ways that exceed expectations.
X	**1**	**2**	**3**	**4**

2d Demonstrate the ability to interpret and use visual data				
No Score	**Emerging**	**Developing**	**Achieving**	**Exemplary**
A score of X designates irrelevancy of the category to the assignment, or folders and/or content cannot be viewed or assessed.	Student demonstrates inability to interpret and use visual data effectively.	Student demonstrates some ability to interpret or use visual data effectively, but does not demonstrate ability in both skills.	Student demonstrates the ability to use and interpret visual data effectively.	Student demonstrates a refined ability to use and interpret visual data in clear, thoughtful, and precise ways that exceed expectations.
X	**1**	**2**	**3**	**4**